THE USE OF INSTRUCTIVE FEEDBACK TO PROMOTE EMERGENT VERBAL RESPONSES: A REPLICATION

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Previous research has incorporated instructive feedback (IF) within mastered listener-by-name trials with two children diagnosed with autism spectrum disorder (ASD). Participants in a previous study acquired the secondary targets and also demonstrated emergent responding (i.e., listener-by-feature, tact-by-feature, intraverbal, and reverse intraverbal). The current study replicated a previous study on IF with two children with ASD. Therapists conducted a series of three sessions of mastered listener-by-name trials (e.g., “Show me otter,” and the participant selecting the picture of the otter) and provided IF statements for features of the target stimuli (e.g., “It lives in rivers.”). We measured participants’ echoic responding and required attending to the target stimulus during IF trials, and we evaluated acquisition of secondary targets and emergent responses using a concurrent multiple probe design across sets. We observed increased correct responding for secondary targets and emergent responses for the first set of stimuli with both participants. However, one participant did not engage in emergent responses for the two remaining sets. Results suggest that related verbal operant response relations of secondary targets may result after IF, but the extent of emergence may be idiosyncratic.

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CHAPTER 1

INTRODUCTION

Because individuals with autism spectrum disorder (ASD) need to learn multiple skills across multiple domains, behavior analytic intervention needs to span a variety of skills. Skill sequences based on developmental stages in classroom curricula are rarely designed to address the specific skills that individuals with ASD need to acquire (Meisels & Shonkoff, 1990). Early intensive behavioral intervention (EIBI) can target needed skills by using behavior-analytic procedures that individualize teaching, target specific skills, and maximize the number of learning opportunities for learners in a brief period of time (Kodak & Grow, 2013).

When planning instruction in EIBI, it is important to consider both the areas of intervention and the resources available to families of individuals with ASD. Behavior analysts must identify and prioritize procedures that are feasible, likely to result in socially significant change, and efficient (Alessi, 1987). Therefore, behavior analysts should seek to utilize effective procedures, which produce desired learning outcomes, and efficient procedures, which produce optimal desired learning outcomes in the least amount of instructional time, when designing EIBI programs for children with ASD (Reichow & Wolery, 2011). Efficiency can be important to prioritize because learners will be likely to amass more complete repertoires in a given duration of intervention. In addition, employing efficient procedures produces a benefit for behavior analysts, teachers, and therapists because they can teach the same number of behaviors in less time and have more time to work on other important skills during an individual's limited treatment time (Wolery et al., 1992).

A teaching approach that has been shown as an effective procedure to teach a variety of skills is discrete-trial instruction (DTI), which is comprised of learn units typically referred to as trials (Smith, 2001). A typical DTI trial consists of a discriminative stimulus (S^D), learner response, prompt, and consequence. When using DTI, the therapist may present the S^D, wait for the learner to respond, provide a prompt if the learner responded incorrectly, and provide a consequence for the correct response. One strategy that can be integrated into DTI that has been shown to be effective and efficient is instructive feedback (IF).

IF builds on a typical DTI trial by including not only one acquisition target (i.e., primary target) but also incorporating additional instructional targets (i.e., secondary targets) which may be programmed to occur in the antecedent or consequence portion of a DTI trial (see Nottingham et al., 2017 and Vladescu & Kodak, 2013 for variations in IF placement). In IF, the learner is not required to respond to the secondary target, and responses, if they do occur, are not reinforced; therefore, secondary targets are not taught directly (Vladescu & Kodak, 2013). In an example DTI trial with IF, the therapist shows the learner pictures of three animals and says, “Touch bear.” (antecedent stimuli and primary target). After the learner touches the picture of the bear (learner’s response), the therapist provides a reinforcer (consequence) and says, “Bears are mammals” (secondary target; IF). The learner is not required to echo “Bears are mammals.” Later, the therapist presents the antecedent verbal stimulus “Bears are…” to probe whether the learner has acquired the IF response.

IF has been shown as an effective and potentially efficient way to acquire new skills. The inclusion of secondary targets may result in more rapid learning because learners can acquire twice (or more; Nottingham et al., 2017) the number of targets in the same amount of time when IF is included (Shillingsburg et al., 2018). Acquisition of secondary targets with IF has been demonstrated in 1:1 and small-group instructional contexts for several populations including individuals of typical development and individuals with disabilities like intellectual disability, ASD, speech and language impairments, learning disabilities, developmental delays, and Down syndrome (e.g., Carroll & Kodak, 2015; Leaf et al., 2017; Nottingham et al., 2017; Nottingham et al., 2020; Tekin Iftar et al., 2003; Werts et al., 2011). Secondary target acquisition with IF has also been demonstrated using several procedural variations such as the number, location, and presentation schedule (Carroll & Kodak, 2015; Nottingham et al., 2017; Nottingham et al., 2020; Vladescu & Kodak, 2013).

IF has been described as a way to increase efficiency of instruction through rapid learning: learners can acquire twice the number of targets in the same amount of time. Additionally, it is possible that efficiency of IF could be enhanced if one arranges and assesses for emergence: the acquisition of nontarget information presented in the instructional context and for which there are no programmed consequences for the learner to acquire that information (Wolery et al., 1992). Arranging and assessing for emergence of verbal operants in an IF program may be an additional avenue to increase the efficiency of skill acquisition. Specifically, learners may be able to acquire the secondary targets and also emit correct responses to related verbal operants that were not directly taught such as a listener discrimination, tact, or intraverbal. Teaching and assessing the acquisition of verbal operants may be an avenue to explore emergence within IF. Verbal operants are maintained by unique antecedent and consequence events, making them functionally independent (Skinner, 1957). As a result, teaching a response under one source of control, such as a tact (i.e., verbal behavior in which the form of a response is under the functional control of a nonverbal S^D), does not necessarily result in the emergence of related verbal operants, such as intraverbals (i.e., verbal behavior in which the form of a response is under the functional control of a verbal S^D that does not have point-to-point correspondence with the verbal stimulus; Skinner, 1957). Nevertheless, researchers have evaluated the emergence of additional operants following instruction of one operant (Grow & Kodak, 2010). For example, Kelley et al. (2007) evaluated the functional independence of mands and tacts for children with developmental disabilities. They taught vocal responses as mands or tacts and conducted generalization probes for each verbal operant across alternate operants, providing subsequent training as needed. They found that the untrained mand/tact relation emerged in 9 of 16 opportunities. Shillingsburg et al. (2018) evaluated the emergence of intraverbal relations following sequential training of new relations (i.e., listener-by-feature/function, tact-by-feature/function, and bidirectional intraverbals). Their results show that some participants engaged in emergent intraverbal response relations following training of the listener and tact responses.

The possibility that IF could lead to emergent responding was evaluated in a recent study by Frampton and Shillingsburg (2020). The researchers embedded tacts of features (secondary targets) within mastered listener discrimination trials (primary targets) and assessed whether intraverbals and reverse intraverbals emerged following IF. Frampton and Shillingsburg conducted the evaluation with two male children (aged 7 and 8 years) who were described as advanced Level Three learners according to their scores on the Verbal Behavior—Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008). The trials with IF were conducted in the following order: (a) the researcher delivered the primary target conditional stimulus, for example, “Show me judge,” in the presence of a three-picture array, (b) the learner selected the judge, (c) the researcher provided praise and a token, and (d) the researcher provided the IF statement pertaining to a feature of the item, in this case “She uses a gavel.” After three sessions of IF, researchers conducted probes on listener-by-feature, tact-by-feature, Wh- intraverbals, and reverse intraverbals. Frampton and Shillingsburg found that both learners emitted more correct responses during probes following IF compared to baseline responding for all three sets of stimuli, and the responses maintained when assessed approximately two weeks later.

These results demonstrated that embedding IF could not only produce acquisition of secondary targets (i.e., listener-by-feature and tact-by-feature) but the emergence of other verbal operants (i.e., Wh- intraverbals) in as few as three IF sessions. The purpose of the current study was to replicate Frampton and Shillingsburg (2020) with additional learners. In addition to the dependent variables measured by Frampton and Shillingsburg, we collected data on corollary behaviors like echoic responses following IF delivery. A strong echoic or self-echoic repertoire may facilitate acquisition of verbal operants (Esch et al., 2013); therefore, the efficacy of IF may depend, at least in part, on the learner echoing vocal IF statements (Haq et al., 2017; Vladescu & Kodak, 2013). Additionally, the results of Haq et al. (2017) suggest that increased levels of attending coupled with echoic responding may increase acquisition of secondary targets during IF instruction. We extended Frampton and Shillingsburg by requiring attending to the visual stimulus prior to IF delivery and including intraverbal fill-in statements in probes because these more simple discriminations typically develop before more complex intraverbals such as Wh- and reverse intraverbal statements (Sundberg & Sundberg, 2011).

CHAPTER 2

METHOD

Participants and Setting

Two children with autism, diagnosed by medical professionals not affiliated with the study, served as participants. At the time of the study, participants were receiving behavior-analytic services at a university-based autism center. Participants were recruited for the study based on treatment goals related to tact and listener responses by feature, function, and class. The experimenters collaborated with the children's Board Certified Behavior Analysts to confirm appropriateness of the goal and identify teaching targets. Parents provided consent for research during service delivery, which was approved by the institution's review board for human subjects, and the current evaluation was approved by the autism center's executive director. Children provided assent by approaching the table for instruction in the absence of challenging behavior. Research sessions were conducted in the participant's designated therapy room (3.3 m x 2.4 m) at the center. Each therapy room included a table and two chairs along with instructional materials and toys.

Clare was a 4-year-old Eastern European American female who had been receiving applied behavior analytic intervention for sixteen months at the center when this study began, not including a 3.5-month interruption due to COVID-19 closure. Clare attended sessions half-day three times a week and transitioned to full-day sessions five days a week halfway through the study. In the home, Clare's family spoke both their native European language and English, and all intervention services were conducted in English. She obtained standard scores of 147 and 106 on the Peabody Picture

Vocabulary Test—Fourth Edition (PPVT-4; Dunn & Dunn, 2007) and the Expressive Vocabulary Test—Second Edition (EVT-2; Williams, 2007) with age-equivalence scores of 5 years and 5 months and 4 years and 3 months, respectively. Clare's responding on the VB-MAPP was in the Level Two range in the mand, echoic, tact, and intraverbal domains. She could emit spontaneous mands for items, emit at least 200 noun or verb tacts, answer at least 25 different Wh-questions, and had a well-developed echoic repertoire (i.e., a score of 95 on the Early Echoics Skills Assessment [EESA]; Esch, 2008).

Miguel was a 5-year-old Hispanic male who had been receiving applied behavior analytic intervention for twelve months at the center when this study began, not including a 3.5-month interruption due to COVID-19 closure. He attended half-day sessions two times per week. In addition to his in-clinic intervention services, Miguel attended a public school four days per week. His family spoke Spanish and English at home, and all intervention services were conducted in English. He obtained standard scores of 79 and 85 on the PPVT-4 and the EVT-2 with age equivalence scores of 3 years and 6 months and 4 years and 3 months, respectively. Miguel's responding on the VB-MAPP was in the Level Two range in the mand, echoic, tact and intraverbal domains. He could emit spontaneous mands for items, emit at least 200 noun or verb tacts, answer 12 Wh-questions, and had a well-developed echoic repertoire (i.e., a score of 100 on the EESA). Both participants demonstrated bidirectional naming prior to the study (i.e., engaging in tact skills after listener training and vice versa; Miguel, 2016).

Materials and Target Selection

Materials included a cardboard divider that measured 30 cm x 46 cm, data sheets, writing utensils, video camera and tripod, participants' preferred tangibles, and stimulus cards (each 5 cm x 9 cm). Each set of stimulus cards consisted of three stimuli that were laminated, colored images of animals (Clare; see Table 1) or community helpers (Miguel; see Table 2) on a white background. Images were found via an internet search engine. Targets included stimuli that corresponded with goals of the participants' clinical programming and were modeled after those selected by Frampton and Shillingsburg (2020). We selected visual stimuli to which the participant could respond to as a speaker and a listener (e.g., "Otter" in response to the S^D and antecedent verbal stimulus "What is it?" and selected otter from an array in response to the conditional stimulus "Touch otter.").

The IF statements were features of each stimulus. We defined features as relative relations to the target picture (e.g., what the target animal ate, where it lived, and the name of their babies; Cooper et al., 2020). For each stimulus, we identified features that could not be observed in the picture (e.g., we did not include fur color as a feature as it could be observed, the picture of the dog did not include kibble; Frampton & Shillingsburg, 2020). One feature was selected per stimulus based on the participant's responding during probes (described below). Each stimulus in a set had a feature that used a different carrier phrase (e.g., "It eats _." "It lives in _." "Its babies are _."; Tables 1 and 2), and the carrier phrases were repeated across sets (e.g., three total "It eats _." targets).

Table 1

Targets for Sets 1-3 for Clare

Set	Stimulus	Operant	Antecedent Verbal Stimulus	IF Statement	Syllables
	Elephant 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which babies are calves?” “Its babies are ___.” “Elephant babies are ___.” “What are elephant babies?” “Whose babies are calves?”	Its babies are calves.	Name: 3 Feature: 4
1	Otter 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which lives in rivers?” “It lives in ___.” “Otter lives in ___.” “Where does otter live?” “Who lives in rivers?”	It lives in rivers.	Name: 2 Feature: 4
	Dog 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which eats kibble?” “It eats ___.” “Dog eats ___.” “What does dog eat?” “Who eats kibble?”	It eats kibble.	Name: 1 Feature: 3
2	Horse 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which babies are foals?” “Its babies are ___.” “Horse babies are ___.” “What are horse babies?” “Whose babies are foals?”	Its babies are foals.	Name: 1 Feature: 4
	Eagle 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which lives in nests?” “It lives in ___.” “Eagle lives in ___.” “Where does eagle live?” “Who lives in nests?”	It lives in nests.	Name: 2 Feature: 4

(table continues)

Set	Stimulus	Operant	Antecedent Verbal Stimulus	IF Statement	Syllables
	Bee 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which eats pollen?” “It eats ___.” “Bee eats ___.” “What does bee eat?” “Who eats pollen?”	It eats pollen.	Name: 1 Feature: 4
3	Deer 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which babies are fawns?” “Its babies are ___.” “Deer babies are ___.” “What are deer babies?” “Whose babies are fawns?”	Its babies are fawns.	Name: 1 Feature: 4
	Panda 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which lives in forests?” “It lives in ___.” “Panda lives in ___.” “Where does panda live?” “Who lives in forests?”	It lives in forests.	Name: 2 Feature: 4
	Goat 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Which eats shrubs?” “It eats ___.” “Goat eats ___.” “What does goat eat?” “Who eats shrubs?”	It eats shrubs.	Name: 1 Feature: 3

Note: Listener-by-feature antecedent verbal stimuli were always presented with a three-stimulus array. Tact-by-feature antecedent verbal stimuli were always accompanied with a picture of the target stimulus.

Table 2

Targets for Sets 1-3 for Miguel

Set	Stimulus	Operant	Antecedent Verbal Stimulus	IF Statement	Syllables
1	Scientist 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who helps make discoveries?” “She helps ___.” “Scientist helps ___.” “How does scientist help? “Who helps make discoveries?”	She helps make discoveries.	Name: 3 Feature: 7
	Construction worker 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who works at a plant?” “He works at ___.” “Construction worker works at ___.” “Where does construction worker work?” “Who works at a plant?”	He works at a plant.	Name: 5 Feature: 5
	Hairstylist 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who uses the clipper?” “She uses ___.” “Hairstylist uses ___.” “What does hair stylist use?” “Who uses the clippers?”	She uses the clippers.	Name: 3 Feature: 6
2	Postal worker 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who helps customers?” “He helps ___.” “Postal worker helps ___.” “How does postal worker help? “Who helps customers?”	He helps customers.	Name: 4 Feature: 5
	Judge 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who works at a courthouse?” “He works at ___.” “Judge works at ___.” “Where does Judge work?” “Who works at a courthouse?”	He works at a courthouse.	Name: 1 Feature: 6

(table continues)

Set	Stimulus	Operant	Antecedent Verbal Stimulus	IF Statement	Syllables
3	Custodian 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who uses a vacuum?” “She uses ___.” “Custodian uses ___.” “What does custodian use?” “Who uses a vacuum?”	She uses a vacuum.	Name: 3 Feature: 6
	Flight attendant 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who helps serve food?” “She helps ___.” “Flight attendant helps ___.” “How does flight attendant help? “Who helps serve food?”	She helps serve food.	Name: 4 Feature: 4
	Veterinarian 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who works at the clinic?” “She works at ___.” “Veterinarian works at ___.” “Where does veterinarian work?” “Who works at the clinic?”	She works at the clinic.	Name: 5 Feature: 6
	Florist 	*Listener-by-feature* *Tact-by-feature* *Name-feature IV Fill-in* *Name-feature IV Wh-* *Reverse IV*	“Who uses pruning shears?” “He uses ___.” “Florist uses ___.” “What does florist use?” “Who uses pruning shears?”	He uses pruning shears.	Name: 2 Feature: 6

Note: Listener-by-feature antecedent verbal stimuli were always presented with a three-stimulus array. Tact-by-feature antecedent verbal stimuli were always accompanied with a picture of the target stimulus.

To arrange stimuli in sets, we used a logical analysis (Cariveau et al., 2020; Wolery et al., 2014). Stimuli were arranged so that target names and IF statements included a similar number of syllables in each set (see Tables 1 and 2). We confirmed that participants could echo the features by conducting echoic probes with each vocal stimulus (Frampton & Shillingsburg, 2020). Visual images selected for each set were arranged similarly across sets (e.g., one animal in each set was facing forward, to the left, and to the right; community helpers holding items, etc.).

Response Measurement and Interobserver Agreement

The main dependent variable in the current study was the frequency of correct independent responses emitted during listener, tact, and intraverbal (fill-ins and Wh-questions) probes (Frampton & Shillingsburg, 2020). Across operants, a correct independent response was defined as the participant emitting a specific target response within 5 s of the antecedent verbal stimulus (see Table 3 for specific operational definitions).

Correct responses could include repeating any portion of the antecedent verbal stimulus. An incorrect response was defined as the participant engaging in any response other than the target response or not engaging in a response within 5 s. Sets were considered mastered if the participant emitted correct independent responses on at least 55% of probe trials (i.e., at least 5/9 correct) across at least three of the following operants: listener-by-feature, tact-by-feature, intraverbal Wh- questions, and reverse intraverbals (fill-in intraverbals were excluded from the mastery criterion because they were not included by Frampton & Shillingsburg, 2020).

Table 3

Operational Definitions of Correct and Incorrect Responses

Operant	Phase	Stimulus Presentation	Operational definitions	
			Correct	Incorrect
Identity matching	Pretest	Arrange three stimuli horizontally on the table behind a divider according to data sheet. Lift divider, say “Match.” and hand the sample picture to the participant	Placing the sample stimulus card on top of or in front of the corresponding card in an array of 3	Placing the sample stimulus card on top or in front of a card other than the corresponding card in the array or not placing the card on any card
Echoic	Pretest	No visual stimulus presented. Present antecedent verbal stimulus according to stimulus name or feature. (e.g., “Say, dog.”; “Say, It eats kibble.”)	Emitting a vocal response with point-to-point correspondence with the antecedent vocal stimulus	Emitting a vocal response that did not have point-to-point correspondence with the antecedent vocal stimulus or not engaging in a vocal response
Tact-by-name	Pretest	Hold one stimulus in front of participant at eye level. Say “What is it?”	Emitting a vocal response that corresponds with the name of the stimulus shown	Emitting a vocal response that does not correspond with the name of the stimulus shown or not emitting any vocal response
Listener-by-name	Pretest and Intervention	Arrange three stimuli horizontally on the table behind a divider according to data sheet. Lift divider and say, “Show me [name].” (e.g., “Show me dog.”)	Touching the stimulus card that corresponds with the animal named from an array of three	Touching a card that does not correspond with the animal named, touching two or more cards successively or simultaneously, or not touching any card
Listener-by-feature	Probes	Touching the stimulus that corresponds with the feature named from an array of three	Touching a card that does not correspond with the feature named, touching two or more cards successively or simultaneously, or not touching any card	Arrange three stimuli horizontally on the table behind a divider according to data sheet. Lift divider and say “Which [feature]?” (e.g., “Which eats kibble?”)
Tact-by-feature	Probes	Held one stimulus in front of participant at eye level. Present antecedent verbal stimulus according to feature. (e.g., picture of dog + “It eats ___.”)	Emitting a vocal response that corresponds with the feature of the stimulus shown	Emitting a vocal response that does not correspond with the feature of the stimulus shown or not engaging in a vocal response

(table continues)

Operant	Phase	Stimulus Presentation	Operational definitions	
			Correct	Incorrect
Intraverbal Fill-in	Probes	No visual stimulus presented. Antecedent verbal stimulus presented as a fill-in statement. (e.g., “Dog eats __.”)	Emitting a vocal response that corresponds with the feature of the stimulus shown	Emitting a vocal response that does not correspond with the feature of the stimulus shown or not engaging in a vocal response
Intraverbal Wh-	Probes	No visual stimulus presented. Antecedent verbal stimulus presented as a Wh-question. (e.g., “What does a dog eat?”)	Emitting a vocal response that corresponds with the feature of the stimulus shown	Emitting a vocal response that does not correspond with the feature of the stimulus shown or not engaging in a vocal response
Reverse Intraverbal	Probes	No visual stimulus presented. Antecedent verbal stimulus presented according to feature-name and Wh-question (e.g., “Who eats kibble?”)	Emitting a vocal response that corresponds with the name of the stimulus shown	Emitting a vocal response that does not correspond with the name of the stimulus shown or not engaging in a vocal response

Note: Correct and incorrect responses had to occur within 5 s of the antecedent vocal stimulus. Reverse intraverbal trials were only conducted as Wh-questions given the nature of the phrasing of the questions.

The criterion for mastery was based on Frampton and Shillingsburg (2020), and it was designed to account for emergent responses tested under extinction conditions. Correct responses were summed for total frequency and divided by total number of opportunities to obtain a percentage. We continued to collect data on correct independent responses following mastery of each set to assess responding across time.

In addition to the frequency of correct independent responses, we collected data on several other responses. Although the primary targets included in intervention were previously mastered, therapists collected data on participants' responding to mastered targets during the intervention session. Independent correct and incorrect responses were defined similar to the listener-by-feature operant (Table 3); however, the antecedent verbal stimulus was the name of the stimulus (e.g., "Otter" rather than "Which lives in rivers?"). Prompted correct responses were defined as the participant imitating the therapist's model of the correct response within 5 s. Prompted incorrect responses were defined as the participant failing to imitate the therapist's model of the correct response, either because they selected an incorrect stimulus or because they did not respond, within 5 s. We also collected data on whether the participant echoed the IF statement during intervention trials. We recorded the occurrence and non-occurrence of echoics on each intervention trial.

A trained research assistant collected data on the participants' responding from video for 39.6% of sessions for Clare and 35.8% of sessions for Miguel. An agreement was scored if both observers recorded the same participant response on a trial (e.g., both scored an independent correct response). A disagreement was scored if both observers scored a different participant response on a trial. We calculated interobserver agreement (IOA) on a trial-by-trial basis by dividing the total number of agreements by the sum of agreements and disagreements and multiplying by 100 to obtain a percentage (Cooper et al., 2020). Mean agreement for intervention sessions was 98% (78-100%) and 100% for independent correct responses, 90.6% (0-100%) and 100% for prompted correct responses, and 97.3% (89-100%) and 100% for echoic responses for Clare and Miguel respectively. Mean agreement was 96.9% (67-100%) for Clare and 97.7% (89-100%) for Miguel for responding during probe sessions.

Independent Variable and Treatment Integrity

The independent variable in the current study was the inclusion of IF within mastered listener responding trials. The instructive feedback statement included a feature of the target stimulus and did not include the name of the target stimulus (e.g., "It lives in rivers," see Tables 1 and 2).

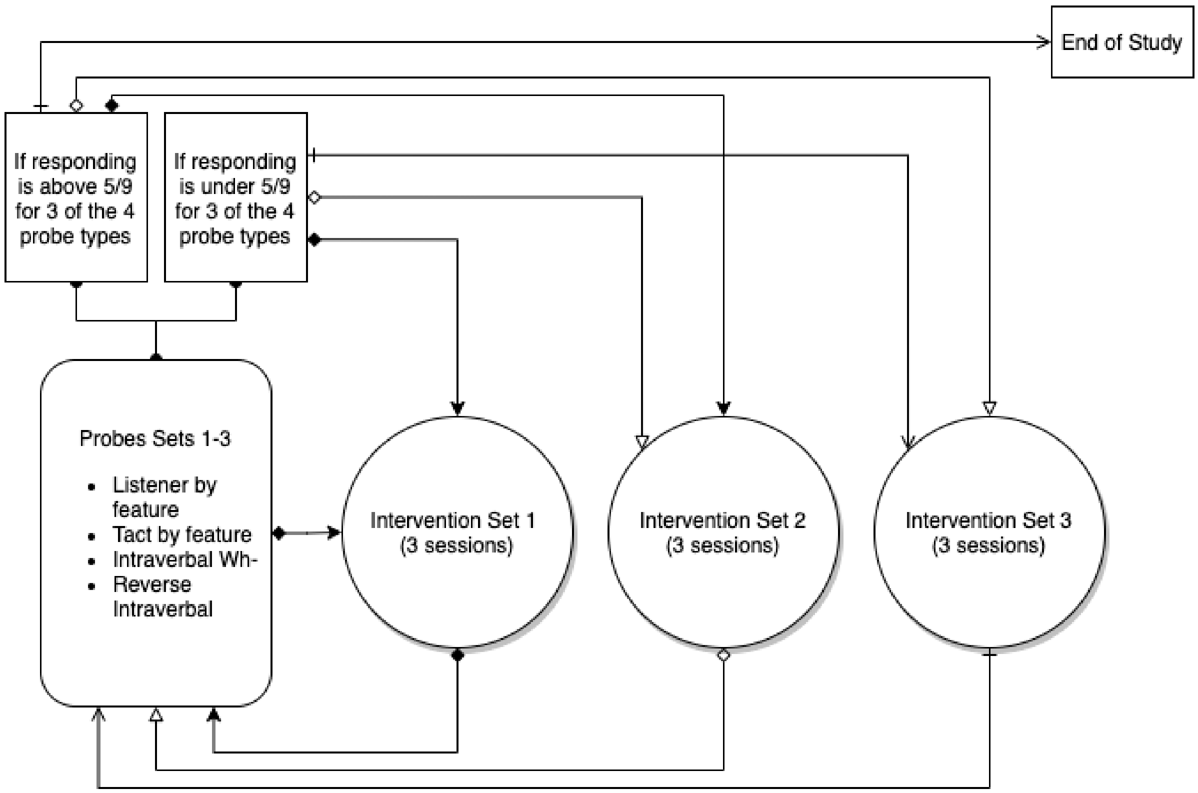
A trained observer collected data on the therapist's implementation of all components of the procedure with a checklist (see Appendix A) across probe, pretest, and intervention conditions for 36.6% and 33.2% of Clare's and Miguel's sessions, respectively. Therapists were trained to run the procedure with integrity using online video models and descriptions of each procedure along with in person role-play practice opportunities. We calculated treatment integrity by dividing the total number of correct components implemented by the therapist by the total number of components per session and multiplying by 100 to obtain a percentage. Mean treatment integrity for intervention sessions was 95% (78-100%) for Clare and 90% (80-100%) for Miguel. Mean treatment integrity for probe sessions was 95.1% (71-100%) for Clare and 96.7% (75-100%) for Miguel. None of the treatment integrity errors were errors in reinforcer delivery during probes (i.e., commission errors). That is, we never reinforced a correct response during a generalization probe. A second observer also recorded treatment integrity during 33.1% of Clare's sessions, to evaluate IOA on treatment integrity measures. An agreement was scored if both observers recorded the same score for a component in the session. A disagreement was scored if both observers scored a different score for a component in the session. These data were calculated by dividing the total number of agreements by the sum of agreements and disagreements and multiplying by 100. Mean agreement on treatment integrity was 96.1% (75-100%).

Design

To evaluate whether instructive feedback led to emergent intraverbal responses, we used a concurrent multiple probe design across sets (Frampton & Shillingsburg, 2020). Baseline assessments were conducted with three sets of stimuli, and therapists measured the participants' responses across operants. Then, therapists implemented one series of intervention with Set 1. Each intervention series consisted of three sessions (i.e., a total of nine exposures to each IF statement). Following one intervention series, therapists conducted probes to assess emergence across operants and sets. If emergence was not observed (i.e., at least 55% correct independent responses emitted for three of four operants [excluding fill-in intraverbals]), then the therapist conducted another intervention series with Set 1 before conducting more probes. Once emergence was observed with Set 1, intervention began with Set 2. This process continued until all sets were exposed to intervention sessions (see Figure 1). Intervention with Clare was discontinued once twice the amount of intervention series with Set 1 had been conducted with Sets 2 and 3 and there was no increasing trend.

Figure 1

Experimental Procedure for Sets 1-3 Including Probe and Intervention Sessions



Note: Procedure begins with Probes of Sets 1-3 and continues along the closed diamond path (Probes, Intervention Set 1, Probes, mastery criterion decision point indicated by the closed circle path, Intervention Set 1 or 2), followed by the open diamond path after responding for Set 1 reaches above 5/9 correct responding (Intervention Set 2, Probes, mastery criterion decision point, Intervention of Set 2 or 3), and ending with the line with an intersected line after responding for Set 2 reaches above 5/9 correct responding (Intervention Set 3, Probes, mastery criterion decision point, Intervention of Set 3 or end of study).

Procedure

We replicated Frampton and Shillingsburg's (2020) procedure with one deviation: we did not use a token system because the clients' behavioral intervention plans prescribed 20-s access to preferred items. Each session included three presentations of each target stimulus (i.e., nine trials). All sessions also included one to two warm-up trials, and probe and pretest sessions included trials with interspersed tasks resulting in a range of 12 to 14 trials per session.

Choice Trial

Before each session, we conducted a choice trial to identify a tangible item to deliver after correct responses according to the reinforcement schedule. Therapists presented an array of three to five preferred items, pointed to each one of the items while providing a tact, and instructed the participant to “Pick one.” Once the participant selected one of the items (i.e., mand for, point to, reach toward, or touch one of the items), the therapist said, “You can play with (item) after you do some work.” and removed all preferred items from the table to initiate warm-up trials.

Warm-up Trials

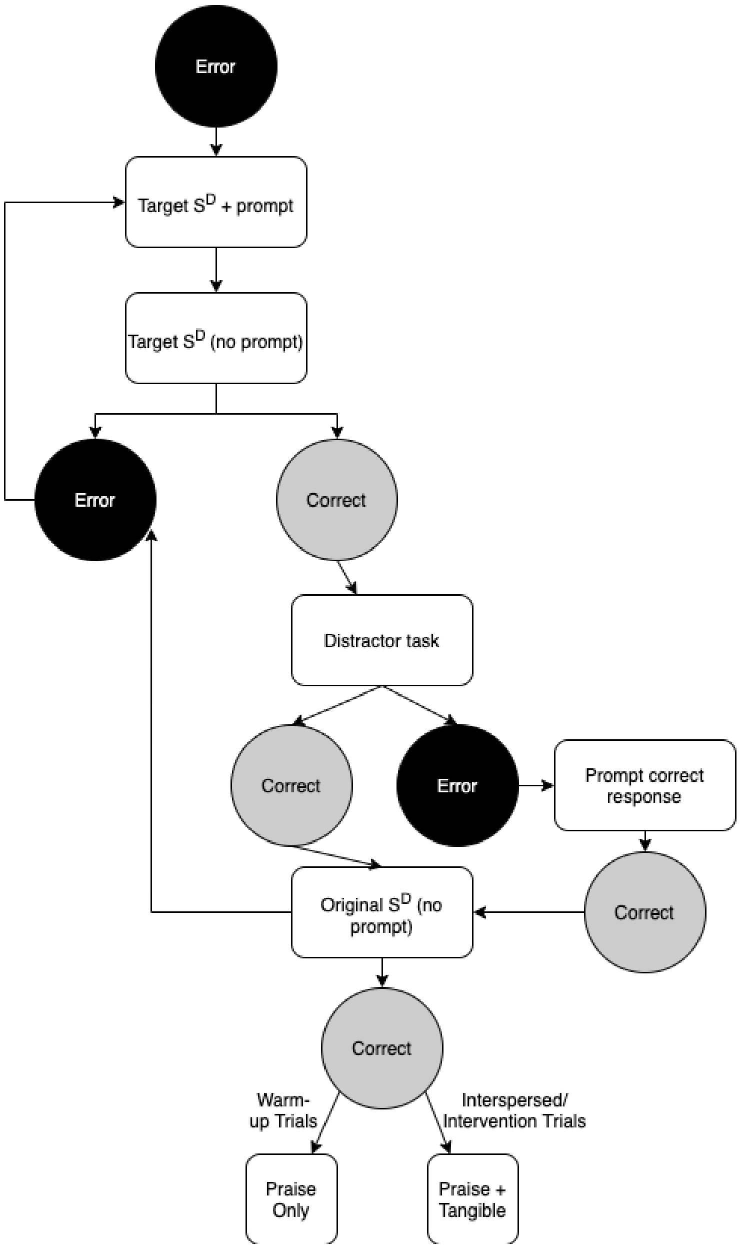
Each session began with one or two warm-up trials. Warm-up trials included tasks that were high-probability requests (e.g., motor imitation, echoics). General praise followed correct responses. If the participant engaged in an incorrect response, the therapist used the error-correction procedure (described below; Figure 2). Regardless of how the participant responded during the warm-up trials, the therapist initiated the next trial after no more than two warm-up trials.

Interspersed-Task Trials

We interspersed trials of unrelated, high-probability tasks (e.g., motor imitation, listener discrimination with and without pictures, echoics, intraverbals, etc.) approximately every three trials in pretest and probe sessions (described below). Therapists delivered general praise and 20-s access to a tangible for independent and prompted responses to interspersed trials. If the participant engaged in an incorrect response, the therapist used the error-correction procedure (described below; Figure 2).

Figure 2

Error-Correction with Transfer Trials Procedure



Note: Curved rectangles depict therapist behavior and circles depict participant behavior.

Error Correction

Error correction followed incorrect responses emitted during warm-up, interspersed-task, and mastered-listener trials (Figure 2). Following an error, the therapist re-presented the S^D and immediately provided a model of the correct response. The therapist then re-presented the S^D without a response prompt to give the participant an independent opportunity to respond. Following a correct response within 5 s of the S^D, the therapist presented a distractor task (i.e., a high-probability response). If the participant engaged in an error during the distractor task, the therapist prompted the correct response. After the distractor task, the therapist again re-presented the S^D. If the participant responded correctly, the therapist provided either general praise (warm-up trials) or general praise and access to a tangible item (interspersed-task and mastered-listener trials). If the participant engaged in an error, the therapist restarted and repeated the error-correction sequence until the participant engaged in an independent correct response to the S^D.

Pretests

We evaluated prerequisite skills with all stimuli in each set (Frampton & Shillingsburg, 2020; Shillingsburg et al., 2018): identity matching, echoics, listener-by-name, and tact-by-name. Sessions included three trials of each target stimulus, one or two warm-up trials, and three interspersed-task trials. Skills were tested in the following order: identity matching, echoics, listener-by-name, and tact-by-name. One skill was assessed with each set (e.g., identity matching with Sets 1, 2, and 3) before moving onto the next skill. The therapist presented antecedent stimuli according to descriptions in Table 3. The participant had 5 s to respond following each S^D. The therapist did not provide any response prompts, and they provided a neutral statement following correct and incorrect responses (see Table 3 for operational definitions). In order to advance to probes, the participant needed to respond correctly on at least 89% of trials within a session across all skills with all sets.

Baseline and Emergence Probes

Baseline and probe sessions evaluated responding across listener-by-feature, tact-by-feature, name-feature intraverbal (fill-in statements and Wh- questions), and reverse intraverbal (Wh- questions) operants. Several trial-order versions for each probe type were created so that stimulus-presentation orders were semi-randomized across probe presentations, but skills were tested in a fixed order: listener-by-feature, tact-by-feature, intraverbal (fill-in statements and Wh-questions), and reverse intraverbals. One probe type was assessed with each set (e.g., listener-by-feature with Sets 1, 2, and 3) before moving onto the next type. No responses were prompted and neutral statements were provided by the therapist (e.g., “Okay.”, “Alright.”) after each response regardless of whether it was correct or incorrect.

Instructive Feedback Intervention

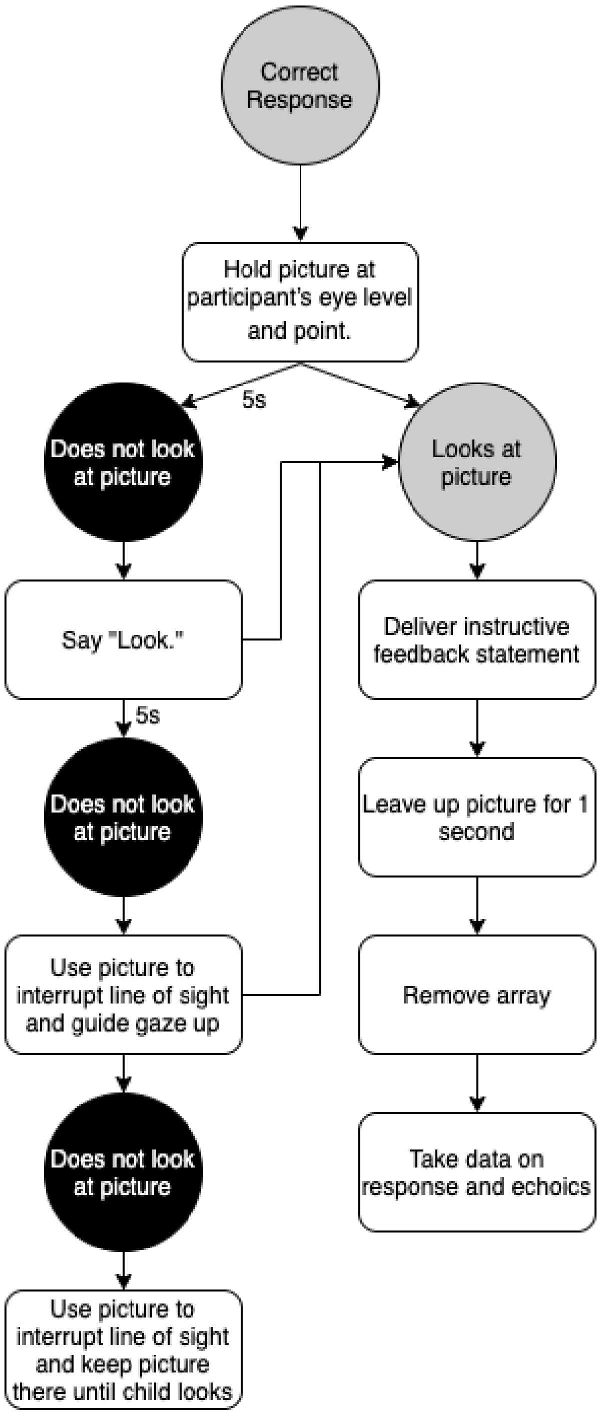
The intervention sessions included mastered listener-by-name discriminations as the primary targets and feature tacts as the secondary targets. These sessions included warm-up trials but no interspersed tasks.

Primary Targets

The procedure for these sessions looked identical to the listener-by name pretest trials (Table 3) except that correct responses were reinforced (see Figure 3). If the participant engaged in a correct response the therapist provided general praise and 20-s access to a preferred item. If the participant responded incorrectly, the therapist used the error-correction procedure; independent and prompted correct responses were followed by praise and preferred items.

Figure 3

Instructive Feedback Delivery Procedure



Note: Curved rectangles depict therapist behavior and circles depict participant behavior. Black circles depict errors and gray circles depict correct responses.

Secondary Targets

Once the preferred item was delivered, the therapist presented the S^D at the participant's eye level while pointing to the stimulus. If the participant did not look at the picture within 5 s of its presentation, the therapist said "Look." If another 5 s elapsed without attending to the picture, the therapist placed the visual stimulus in front of the preferred item until they looked at the picture. Once the participant looked at the picture, the therapist delivered the IF statement, which included the target feature of the stimulus (see Tables 1 and 2). The IF statement did not repeat the name of the stimulus (e.g., "It eats shrubs" instead of "Goat eats shrubs"). After the IF statement was delivered, the experimenter removed the picture after 1 s, removed the other pictures in the array, collected data on the participant's responses, and engaged with the participant for the remainder of the time with the preferred item.

Participant-Specific Modifications

Based on the participant's responding during probe conditions, we modified the procedures to try to evoke correct responses in the presence of relevant antecedent conditions. These modifications occurred during probes only, and the intervention sessions remained unchanged.

Response to Errors - Trial Removal (Clare)

After four intervention series with Set 1 (probe 1.4), we noticed Clare was engaging in unintelligible vocalizations or saying "okay" with a short latency after most presentations of the S^D or antecedent verbal stimulus across probe types and sets. Therefore, we modified how therapists responded to incorrect responses during probes so that non-target vocalizations no longer resulted in immediate presentation of the neutral statement and termination of the trial. Specifically, all unintelligible vocalizations and “okay” resulted in the full 5 s response interval before the therapist provided a neutral statement and moved onto the next trial.

After four intervention series with Set 2 (probe 2.4), we modified how therapists responded to incorrect responses during probes again, this time including repetitive, unrelated vocalizations (e.g., “Mommies, and daddies, and babies.”). Therefore, every non-target vocalization resulted in the full 5-s response interval regardless of whether the participant emitted intelligible words.

Interspersed-task Trial Ratio (Clare)

After six intervention series with Set 3 (probe 3.6), Clare stopped emitting vocal responses on most probe trials. We became concerned that she was no longer responding due to the thin reinforcement schedule in place during probes compared to most of her intervention sessions (i.e., variable ratio 3 for probes compared to a fixed ratio 1 for intervention and other programs). Therefore, we increased the density of reinforcement delivered each session by increasing the number of interspersed tasks to seven per session. This change increased sessions to 17-18 trials.

Differential Reinforcement (Clare)

When we did not observe correct responding reach criterion for Sets 2 and 3 after eleven and ten intervention series, respectively, under extinction conditions, we added differential reinforcement to the probe sessions (Mitteer et al., 2020). If Clare emitted a correct response on a probe trial, the therapist provided praise and access to a tangible item rather than providing a neutral statement. We did this to determine if adding reinforcement to probes would increase the accuracy of her responses during probe trials.

Extended Response Interval (Clare)

Clare was not emitting vocal responses reliably when we added differential reinforcement; therefore, we made a final modification to increase the response interval. Now, Clare had 10 s to respond in probes rather than 5 s (Gorgan & Kodak, 2019).

CHAPTER 3

RESULTS

Clare

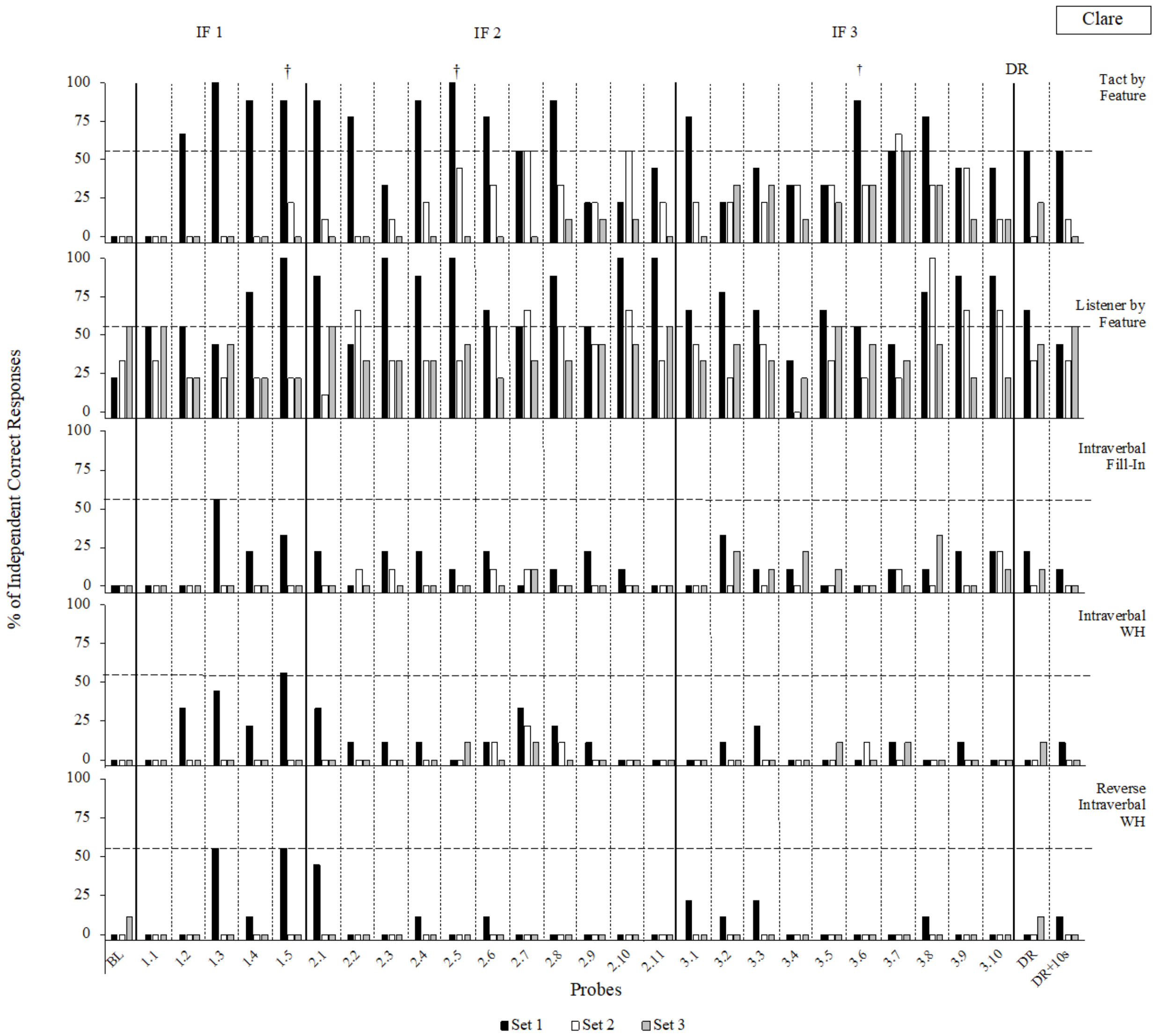
Figure 4 depicts the results of Clare's emergent responding during probes (correct responding during the intervention sessions and data on echoic responding during intervention is included in Figure 5). During baseline (BL probe), Clare emitted low levels of correct responses across all sets and operants; none of the responses emitted in listener-by-feature sessions exceeded chance levels.

Set 1

After introducing intervention with Set 1 (probe 1.1), Clare emitted more correct responses—without exceeding chance-level responding—in the Set 1 listener-by-feature discrimination, and we saw no changes in her responding across other operants. Following her second intervention series with Set 1 (probe 1.2), correct responding increased for tacts-by-feature and Wh-intraverbals for Set 1. After a third intervention series with Set 1 (probe 1.3), correct responding increased for tacts and all three intraverbals. With a fourth intervention series (probe 1.4), responding decreased across all operants except listener responding. We made the modification to operational definitions and all intelligible responses and "okay" resulted in the full 5-s response interval, shown with an asterisk on the graph. Following her fifth intervention series (probe 1.5), Clare's responding reached the mastery criterion (i.e., at least 55% correct responding across three operants) for Set 1. Therefore, five intervention series (i.e., 15 sessions; 45 exposures to each IF statement) were necessary before correct responding exceeded 55% in probes across operants.

Figure 4

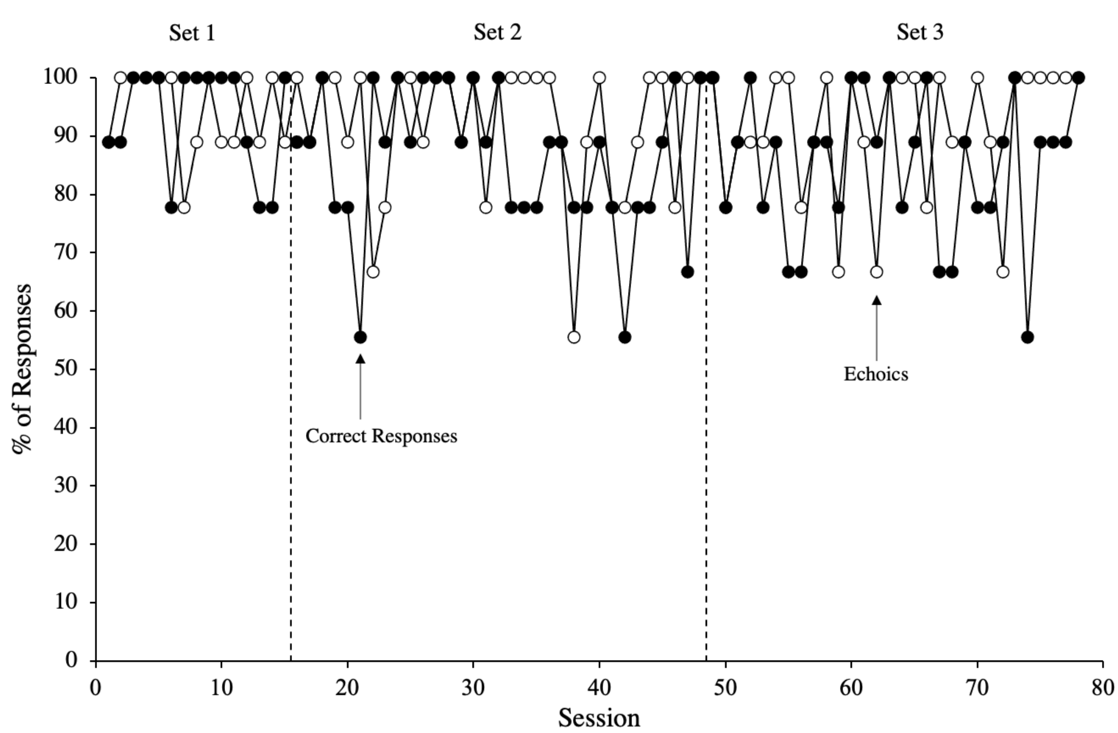
Results of Emergence Probes for Clare



Note: The introduction of Intervention is indicated by a solid line. Each cross indicates when a modification to probes was made. DR indicates differential reinforcement.

Figure 5

Percentage of Correct Responding and Echoics during Intervention across Sets for Clare



Clare's responding for mastered listener discriminations and echoics during intervention is included in Figure 5. Correct responding for Set 1 ranged from 78%-100% across sessions, with a mean of 93%. She emitted echoics of the IF statement for 78%-100% of trials with a mean of 94%.

Set 2

After introducing intervention with Set 2 (probe 2.1), Clare's correct responding did not exceed baseline levels. After her second intervention series with Set 2 (probe 2.2), correct responding increased for listener discriminations above mastery level. After a third intervention series with Set 2 (probe 2.3), correct responding increased for tacts and intraverbal fill-ins and decreased to chance levels for listener discriminations. After a fourth series of intervention with Set 2 (probe 2.4), correct responding increased for tacts, maintained for listener discriminations and decreased for intraverbal fill-ins. However, we noticed that her response patterns shifted from "okay" and unintelligible vocalizations to intelligible, repetitive vocalizations with a short latency. We modified operational definitions so that every non-target vocalization resulted in the full 5-s response interval regardless of whether the client emitted intelligible words (depicted as an asterisk on the graph). After her fifth intervention series with Set 2 (probe 2.5), correct responding for tacts increased. After her sixth intervention series with Set 2 (probe 2.6), correct responding increased above criterion levels for listener discriminations and increased slightly for intraverbal fill-ins and Wh- operants. After a seventh intervention series (probe 2.7), correct responding increased at or above criterion levels for listener discriminations and tacts but remained below criterion for all intraverbals. After an eighth and ninth intervention series (probe 2.8 and 2.9), correct responding decreased across all operants. After a tenth intervention series (probe 2.10), correct responding for listener discriminations and tacts returned to mastery levels, but remained at 0% for all intraverbals. We exceeded the termination criteria because of the increasing trend in Clare's correct responding for the listener discriminations and tacts and conducted an eleventh intervention series (probe 2.11). Nevertheless, correct responding decreased across all operants during probe sessions. Following this decrease, we discontinued intervention for Set 2 after 11 intervention series (i.e., 33 sessions; 99 exposures to each IF statement). Clare's correct responding for Set 1 listener discriminations and tacts maintained over subsequent probe sessions without additional intervention sessions for Set 1, whereas her responding across intraverbal operants decreased.

Clare's responding for mastered listener discriminations was more variable for Set 2, ranging from 55%-100% with a mean of 86% correct (Figure 5). She emitted echoics of the IF statement for 55%-100% of trials with a mean of 91%.

Set 3

After introducing intervention with Set 3 (probe 3.1), responding for Set 3 probes remained unchanged. After a second intervention series with Set 3 (probe 3.2), correct responding increased for listener discriminations, tacts, and intraverbal fill-ins for Set 3. After a third intervention series with Set 3 (probe 3.3), correct responding for listener discriminations and intraverbal fill-ins decreased while responding for tacts remained unchanged. After a fourth intervention series with Set 3 (probe 3.4), correct responding continued to decrease for listener discriminations and tacts and returned to previous levels for intraverbal fill-ins. After a fifth intervention series with Set 3 (probe 3.5), correct responding reached mastery levels for listener discriminations, increased for tacts and Wh- intraverbals and decreased for intraverbal fill-ins. After a sixth intervention series with Set 3 (probe 3.6), correct responding increased for tacts and decreased across all other operants. We increased the density of reinforcement delivered each session by increasing the number of interspersed tasks to seven per session (depicted as an asterisk on the graph). After a seventh intervention series with Set 3 (probes 3.7), correct responding reached criterion levels for tacts, returned to previous levels for Wh- intraverbals, and continued to decrease for listener discriminations. After an eighth intervention series with Set 3 (probes 3.8), correct responding increased for listener discriminations and intraverbal fill ins and decreased across all other operants. After a ninth intervention series with Set 3 (probes 3.9), correct responding decreased across operants or remained at 0%. After a tenth intervention series with Set 3 (probes 3.10), correct responding remained unchanged. We discontinued probes under extinction conditions for Set 3 after ten intervention series (i.e., 30 sessions; 90 exposures to each IF statement) to avoid exposing Clare to continued ineffective conditions.

Clare's responding for mastered listener discriminations for Set 3 was as variable as responding for Set 2, with correct responses ranging from 55%-100% with a mean of 85% correct (Figure 5). She emitted echoics of the IF statement for 67%-100% of trials with a mean of 91%.

Differential Reinforcement

We conducted one series of probes using differential reinforcement (DR probe). Correct responding for Set 3 increased for listener discriminations, tacts, Wh-, and reverse intraverbals but not above levels we had seen previously. Correct responding did not reach criterion for any of the operants.

Extended Response Interval

We conducted an additional probe series using differential reinforcement with a 10-s response interval. Correct responding met criterion for listener discriminations, but correct responding decreased across all other operants. Because Clare's correct responding did not increase above levels previously observed during probes under extinction, and we had reinforced correct responding, we concluded our probe sessions. Clare was taught the remaining targets as part of her intervention programming outside of the study.

Miguel

Figure 6 depicts results of emergence probes for Miguel (correct responding during the intervention sessions and data on echoic responding during intervention is included in Figure 7). During baseline (BL probe), Miguel emitted low levels of correct responses across all sets and operants; none of the responses emitted in listener-by-feature sessions exceeded chance levels. He engaged in one correct response during Set 1's reverse intraverbal probes and Set 2's intraverbal fill-in and Wh- probes.

Set 1

After introducing intervention with Set 1 (probe 1.1), Miguel emitted more correct responses for Set 1 across probe types. His correct responding for Set 1 increased above criterion levels for listener discriminations and tacts. His correct responding for Set 2 reverse intraverbals also increased to criterion levels despite no exposure to the corresponding Set 2 IF statements. After a second intervention series with Set 1 (probe 1.2), Miguel's correct responding increased across all operants and met criterion for listener discriminations, tacts, and reverse intraverbals. Two intervention series (i.e., 6 sessions; 18 exposures to each IF statement) were necessary before correct responding exceeded 55% in probes.

Miguel's responding for mastered listener discriminations and echoics during intervention is included in Figure 7. Correct responding for Set 1 ranged from 78%-100% across sessions, with a mean of 89%. He emitted echoics following nearly every IF presentation during intervention.

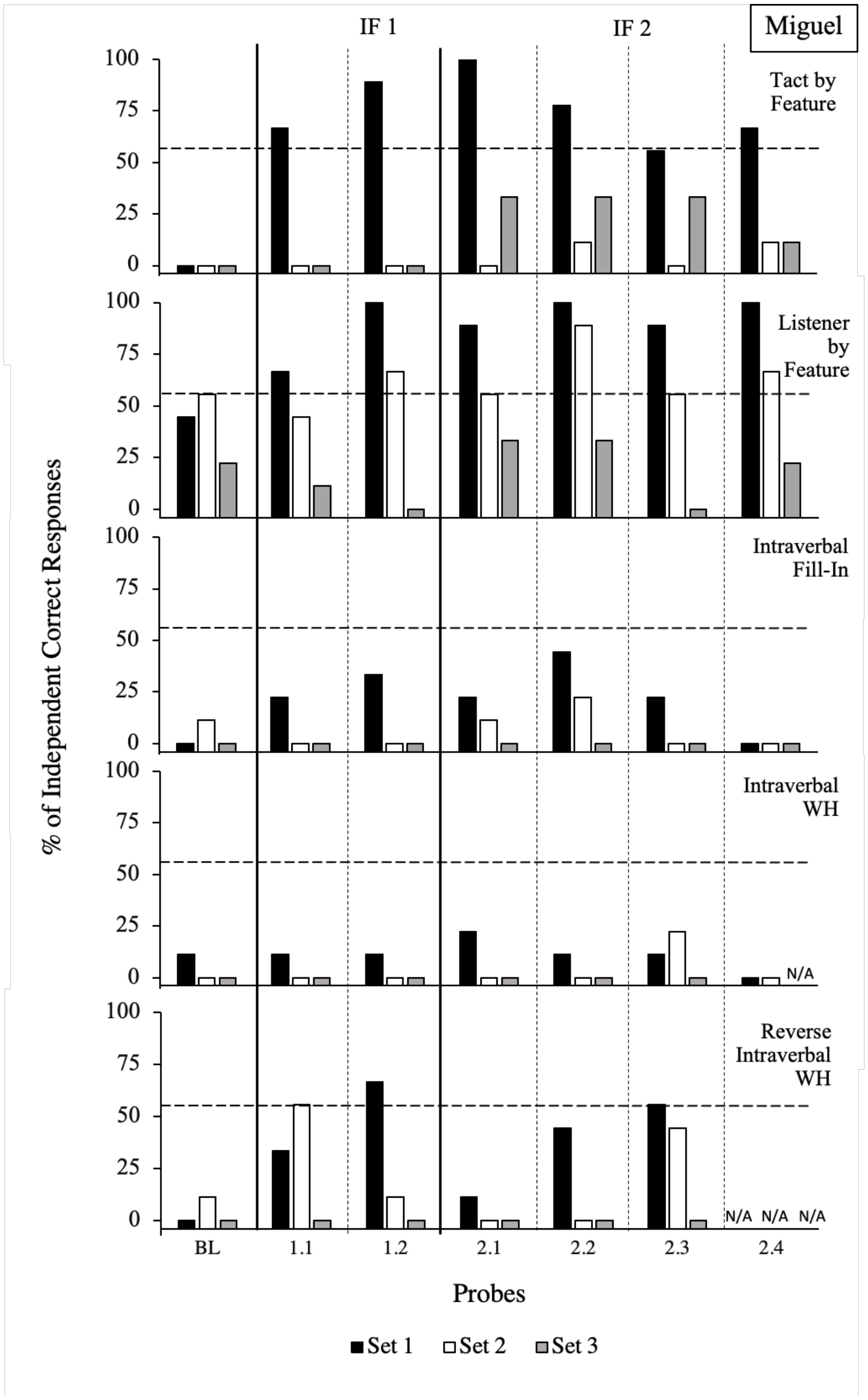
Set 2

After introducing intervention with Set 2 (probe 2.1), Miguel's correct responding for Set 2 met criterion for listener discriminations and increased for intraverbal fill ins but remained unchanged for all other operants. After a second intervention series with Set 2 (probe 2.2), correct responding for listener discriminations, tacts, and intraverbal fill ins increased. After a third intervention series with Set 2 (2.3), correct responding for Wh- intraverbals increased but decreased across all other operants. After a fourth intervention series with Set 2 (2.4), correct responding for listener discriminations increased. We were unable to complete Wh- intraverbal and reverse intraverbal probes due to the participant's extended absence from receiving services.

Miguel's responding for mastered listener discriminations for Set 2 ranged from 78%-100% across sessions, with a mean of 92%. He emitted echoics for almost 100% of trials (Figure 7).

Figure 6

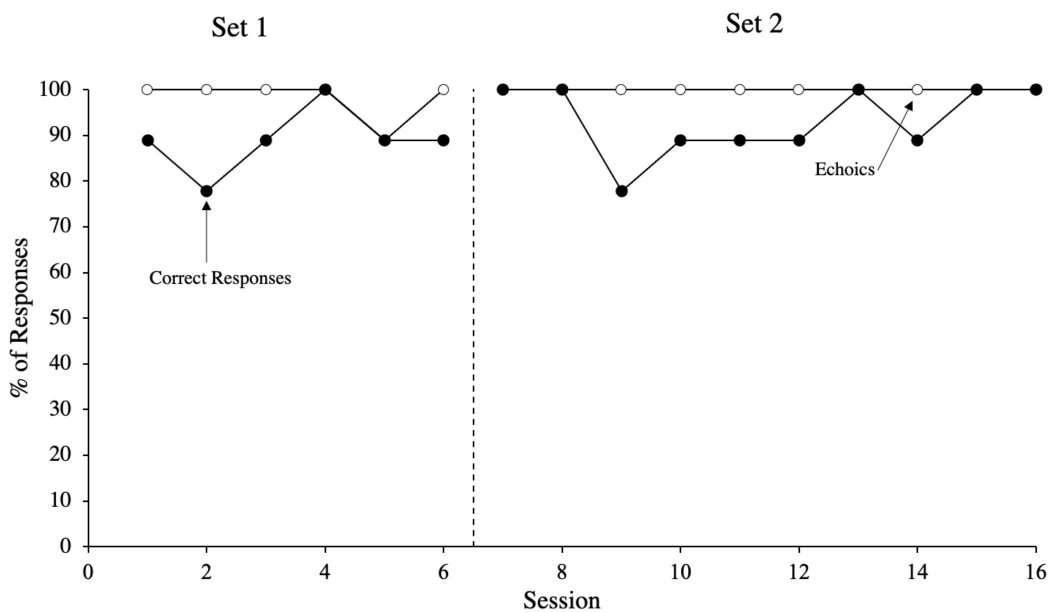
Results of Emergence Probes for Miguel



Note: The introduction of Intervention is indicated by a solid line.

Figure 7

Percentage of Correct Responding and Echoics during Intervention across Sets for Miguel



CHAPTER 4

DISCUSSION

Adding IF to mastered listener-by-name trials produced increased correct responding across secondary and emergent operants with the first set of stimuli for both participants. However, Clare's correct responding did not reach criterion levels for Set 2 nor Set 3 despite experiencing twice the intervention sessions compared to Set 1. Miguel's correct responding met criterion levels for Set 1 in two intervention series, but his responding for Set 2 did not reach criterion after four intervention series. Unlike Frampton and Shillingsburg (2020), we did not see emergence after a single series of intervention with either of our participants, and we had to conduct additional intervention series before we observed emergent responses. Therefore, our findings partially replicated Frampton and Shillingsburg in that emergent responses were observed following IF for some sets but not all and not to the degree nor with the same speed of acquisition.

One of the mechanisms that may account for the increased responding that we did observe is bidirectional naming. Both participants had demonstrated bidirectional naming (i.e., engaging in tact skills after listener training and vice versa; Miguel, 2016) prior to the study. The IF we provided was a tact-by-feature response (e.g., "It lives in rivers." in the presence of the otter). Participants' overt echoic responses under the control of the IF and in the presence of the target picture during intervention may have established tact-by-feature responses (e.g., echoing "It lives in rivers." in the presence of the picture of the otter may increase the likelihood of emitting the tact "rivers" when presented with the antecedent verbal stimulus "It lives in__." and the picture of the otter). Given that we required attending to the target picture before delivery of the IF statement, participants may have behaved as listeners when the IF statement was presented (e.g., because the participant looked at the picture of the otter while the statement "It lives in rivers," was presented, and echoed "river" in the presence of the picture of the otter during intervention, they may be more likely to select the otter when the therapist asks, "Which lives in rivers?"). Their ability to tact the name of the feature, exposure to the antecedent verbal stimulus during listener-by-feature trials, and history of bidirectional naming may have made it more likely for participants to select the correct stimulus during listener-by-feature probes if they could tact the name of the feature in the presence of the corresponding stimuli.

Echoic and self-echoic responses may promote correct emergent tact, listener discrimination, and intraverbal responses. Frampton and Shillingsburg (2020) observed emergent verbal operants, but their participants did not emit overt echoic responses during the IF intervention. Instead, Frampton and Shillingsburg suggested that covert echoics and self-echoics could have occurred given the participants' repertoires. Because Haq et al. (2015) found a relationship between echoic responses and secondary target acquisition, we measured echoics emitted during the IF intervention for both of our participants. Clare emitted echoics for 94% of trials with Set 1 and 2 and 91% of trials with Set 3 and Miguel emitted echoics for almost 100% of trials with both sets. Despite emitting echoics following most IF presentations, we did not see emergence of intraverbals like that found in Frampton and Shillingsburg (2020). Overt echoic responses may have come under control of the picture through transfer of stimulus control after repeated exposures to the statement during intervention sessions.

Intraverbal responses may have emerged due to a combination of a covert tact of the name of the stimulus and overt tact of the feature (e.g., emitting the covert response "otter" and overt response "rivers" in the presence of the picture of the otter) emitted in close temporal contiguity, which may have been enough to establish the emergent intraverbal responses (Palmer, 2016). Despite our participants engaging in overt echoics of the IF statement, they may not have been engaging in covert self-echoics after delivery of the corresponding S^D. Our use of tangible reinforcers may have affected the occurrence of these echoics and self-echoics .

Most previous literature has evaluated IF using token or edible reinforcers (e.g., Frampton & Shillingsburg, 2020; Loughrey et al., 2014; Nottingham et al., 2017; Nottingham et al., 2020; Vladescu & Kodak, 2013), but there are some examples of effective IF demonstrations that utilized tangible items (e.g., Carroll & Kodak, 2015; Delmolino et al., 2013; Haq et al., 2015). The studies that incorporated tangible items reported increased responding during secondary target probes, but none evaluated emergent operants. One of the reasons that our participants may have responded differently to the IF intervention than the participants in the study by Frampton and Shillingsburg (2020) is that we used tangible items during reinforcer intervals rather than tokens. Tokens are delivered in a short period of time and edibles are quickly consumed, so in either case, the participant does not have a competing stimulus in the environment to engage with during IF presentation. In contrast, when using tangibles during the reinforcer interval, the participant has preferred stimuli competing with the target stimuli presented, and the type of tangible may differentially affect the probability of an echoic response. For example, Clare emitted fewer echoic responses (i.e., during

28% of trials) when she had access to the tablet during the reinforcer interval compared to when she selected other types of tangibles (see Appendix B). Future research should consider these differences and evaluate the use of IF with different types of reinforcers to learn more about the contexts most likely to produce secondary target acquisition and emergent responding.

More advanced intraverbal repertoires may be needed before intraverbals across multiple sets of stimuli are likely to emerge following IF because of the conditional control required to respond correctly. That is, the emergent intraverbal responses probed consisted of more complex intraverbals including convergent control: multiple components of one speaker's verbal behavior control a specific verbal response from another speaker (e.g., the therapist asks, "Where does otter live?" "Where does eagle live?" and "Where does panda live?" and correct responses should be controlled by both the word "live" and the name of the animal; Michael et al., 2011). These conditional discriminations may account for increased intervention sessions or no acquisition with Sets 2 and 3 (Axe, 2008). Patterns of responding during probes could suggest that participants' intraverbal responses were not under conditional control. For example, Clare responded "kibble," a correct response for Set 1, across Set 2 and Set 3 probes with the carrier phrase "eats," and Miguel responded "clippers," a correct response for Set 1, across Sets 2 and 3 with the carrier phrase "uses," and this carried over into probes after intervention with Set 2. We observed both participants engage in correct tacts and listener discriminations before correct responding increased for intraverbals. DeSouza et al. (2019) evaluated the effects of training prerequisite skills suggested by Sundberg and Sundberg (2011) on the emergence of convergent intraverbals. One prerequisite is that the target be evoked under divergent control (i.e., the strengthening of more than one response by one stimulus; Michael et al. 2011) through intraverbal categorization (e.g., “Tell me some animals;” “Tell me where things live”). Another prerequisite is responding correctly to the convergent statement as a listener (e.g., “Who lives in rivers?”). DeSouza et al.’s results suggest that convergent intraverbals did not occur until participants responded correctly to the last prerequisite skill, which may suggest that all four skills must be present before emergent intraverbals occur. It is possible that our learners did not engage in emergent intraverbals as quickly due to a lack of these final two prerequisite skills.

Clare and Miguel both emitted echoics, correct responses to Wh-questions, fill-in intraverbals, tacts and listener discriminations by feature, and demonstrated bidirectional naming but their vocal verbal repertoires were likely less advanced than the participants in Frampton and Shillingsburg (2020) (e.g. advanced Level Three learners with total scores of 163 and 146.5 on the VB-MAPP). Differences in their repertoires could account for differential effectiveness of the IF arrangement and emergent responses. Future research may include additional assessments to determine incoming repertoires and help determine for whom this IF intervention is likely to produce emergent operant responses.

Miguel emitted correct responses to Set 2 reverse intraverbals before the IF intervention, and this was similar to Toby’s correct responding in Frampton and Shillingsburg (2020). Given the sequence of our probes, participants had exposure to the reverse intraverbal S^D in the presence of three target pictures during listener-by-feature probes (e.g., “Who lives in rivers?” with an array of otter, dog, and elephant present). This exposure may have been enough to transfer control of the feature to one of the stimuli whose name was then emitted during reverse intraverbal probes (e.g., “Who lives in rivers?” “Otter.”) or temporarily strengthen responses. Future research should consider varying the order of probes to avoid potential carryover effects.

Another variable that may affect emergent responding involves the stimuli selected for programming. The ability to do so may impact whether emergent intraverbals are observed (DeSouza et al., 2019). Researchers should consider including secondary targets that are already in the participants’ repertoires in some capacity. We probed the features as listener and tacts trials with Clare after completion of all probes, and she responded correctly to the features on 89-100% of trials (see Appendix C). However, we do not know whether she could respond as a listener and a speaker to these stimuli prior to the study. Future studies should evaluate whether participants can tact the features selected prior to the onset of the study (e.g., the participant could tact “river” prior to assigning it as the otter’s feature). Researchers may consider selecting secondary targets that are more easily arranged as visual stimuli before moving on to stimuli that are more difficult to display as an image. It may be easier for participants to acquire emergent relations if they can tact all the stimuli involved in them (e.g., can tact “dog,” “kibble,” and the action to “eat” when the secondary target is “Dog eats kibble”) rather than relations with unknown components.

Arranging and assessing for emergence of verbal operants within IF may increase the efficiency of skill acquisition. In our study, Clare met our mastery criterion of 55% correct responding across three of the four operants for Set 1 with 45 exposures to the IF per target. Clare received 99 and 90 exposures to Set 2 and 3 IF statements, respectively, yet she did not meet criterion with these sets. Miguel met our mastery criterion with 18 exposures per target for Set 1. Miguel received 36 exposures to Set 2, and did not meet the criterion. Compared to a session duration of three weeks (Frampton & Shillingsburg, 2020), the current replication required 26 weeks and 14 weeks from stimulus identification to final probes for Clare and Miguel, respectively. Whereas our participants required two to five times more exposures to the IF compared to the participants in Frampton and Shillingsburg (2020), the procedure may still be as or more efficient compared to other IF studies. For example, Carroll and Kodak (2015) used IF to teach response variability for intraverbals, and their participants reached their criterion after 50 and 170 exposures to the IF respectively. Haq et al., (2017) used IF to teach unknown tacts and intraverbal fill-ins and reported participants reached criterion after 69 and 30 exposures per target, respectively. However, these comparisons should be approached with caution as we did not require the participants to meet more stringent mastery criterion (e.g., 90% across three consecutive sessions; Carroll & Kodak, 2015). Future research should look at the number of exposures to trials during acquisition (Kodak et al., 2020) and probes. Additionally, we did not compare the duration of instruction of teaching the verbal operants directly without the IF arrangement, so we cannot compare whether our use of IF is more or less efficient to teaching all targets directly. Efficiency could be enhanced if acquisition tasks are included as primary targets rather than mastered tasks (Albarran & Sandback, 2019); however, analyses of emergent responses when acquisition tasks are included should be explored.

We made several procedural modifications to Clare's probe conditions. Modifying the probe procedures strays from the method used by Frampton and Shillingsburg (2020) and could be considered a limitation. On the other hand, the goal of the study was to evaluate emergent responding. Therefore, individual modifications may need to be made to arrange conditions that are likely to evoke responses in the learner's repertoire. Based on Clare's responding observed in probes (i.e., unintelligible vocalizations, short latency responses, repeated responses), we hypothesized that the function was to remove the trial and end probe sessions earlier (i.e., putative escape-maintained behavior). These observations were coupled with some variable and decreasing responding to interspersed-trial tasks (see Appendix D), which could have suggested that negative reinforcement was a more effective reinforcer than tangible items in the moment (Lalli et al., 1999). Therefore, we modified the probe conditions to no longer remove the trial before the end of the 5-s response interval and increased the density of interspersed mastered tasks (Ingvarsson et al., 2009). Nevertheless, we did not see increased correct responding during probes save for Set 1. Our final modification during probes was to include differential reinforcement for correct responses (Mitteer et al., 2020). We did this to see whether correct responding increased when responses contacted reinforcement. Although we did see Clare engage in some correct responses during this probe, her responding did not increase even when the response interval was extended to 10 s. Her responding during probes could suggest that she did not acquire the verbal operants through IF, and it could be that we did not have an effective reinforcer. We used choice trials (Frampton & Shillingsburg, 2020), but we did not conduct a separate reinforcer assessment. It is also possible that we did not see increases in correct responding during probes because we did not program indiscriminable contingencies (Stokes & Baer, 1977).

The unreinforced verbal operant trials arranged in probes could have been highly discriminable from the reinforced interspersed-task trials. All probe trials were conducted with the same sets of visual and vocal stimuli, there were no prompts or error correction, all responses were followed by a neutral statement, and no responses were followed with reinforcement. In contrast, all interspersed tasks were conducted with different stimuli, incorrect responses were followed by prompts and error correction, and correct prompted and unprompted responses were followed with praise and access to a tangible item. Research on interspersing mastered tasks within teaching has inconsistent findings on which ratio, if any, produces the most efficient learning arrangement, with a recent study suggesting that no task interspersal was the most efficient for participants (Knutson et al., 2019). In addition, the number of probes was extensive and the order was always the same. These arrangement may not be a concern if only a few series are done, as was the case in Frampton and Shillingsburg (2020), but these arrangements may be problematic when there are more exposures and experience with extinction conditions. Our probes were conducted under extinction conditions to assess for emergent responding without potential learning from contingencies of reinforcement. However, this may not be ideal when conducting a large volume of probes for an extended period of time, as we did with Clare. Future studies may explore the number and types of mastered tasks interspersed within probes to decrease the discriminability of reinforced trials during probe sessions (e.g., present only mastered intraverbals for intraverbal sessions or only mastered tacts for tact sessions as the interspersed tasks, or remove prompts after incorrect mastered tasks).

Additionally, reinforcement thinning may also aid in making probe conditions more indiscriminable (LeBlanc et al., 2002), and future research may consider evaluating the use of thinning schedules to improve generalization.

Some limitations of the current study should be considered. We used a logical analysis to assign target stimuli and their features and increase stimulus disparity, but we did have some sets with overlapping features for Miguel (e.g., in Set 1, the construction worker and the hair stylist were pictured crossing their arms; in set 3 the florist and veterinarian are holding items to the same side). We also had some overlapping sounds for responses within the same set (e.g., “florist “and “flight attendant” for Miguel and “calves” and “kibble” for Clare). These stimulus parameters may make some sets easier or harder to acquire and could affect the accuracy and speed of acquisition between sets. It may be more difficult to learn discriminations when there is less disparity between the auditory and visual stimuli included in the set. Future research should attempt to use highly disparate stimuli without overlapping features to avoid introducing additional variables that may affect acquisition and response emission under probe conditions (Halbur et al., 2021).

In conclusion, IF can be an effective way to teach target skills and acquire secondary targets along the way (Werts et al., 1995). Additionally, IF can be arranged to evaluate and produce related and emergent relations, including more complex intraverbals. Future research should continue to explore the behavioral mechanisms behind IF, arrangements to best program and assess for generalization, and for whom IF may be beneficial. These procedural refinements could lead to improved efficiency in behavior-analytic instruction and help guide practitioners to incorporate IF in their practice.

APPENDIX A

TREATMENT INTEGRITY ALL-OR-NONE BY COMPONENT CHECKLIST

All-or-none by Component

Data Collector:
Date:
Condition: Pretests Probes Intervention
MTS Echoic AVCD Tact

Session #:

Data Collection Key:
(+) Component performed correctly 100% of the time
(-) Component performed incorrectly at least once
(N/A) Component not applicable
(N/V) Component not visible during all trials that session

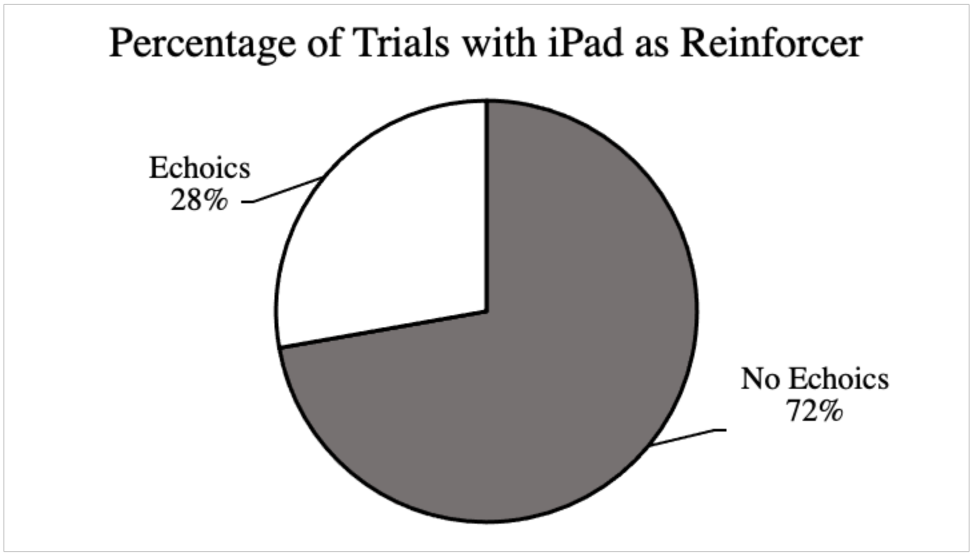
	Component	+ , - , N/A or N/V
1	Presents warm-up trials appropriately. ☐ Presents SD ☐ Provides praise	Choose an item.
2	Presents stimuli appropriately. ☐ Array and sample stimulus for MTS ☐ Array for AVCD ☐ Stimulus for Tacts ☐ N/A for intraverbals	Choose an item.
3	Presents the correct SD according to data sheet.	Choose an item.
4	Provides neutral statement after correct, incorrect, and no response probe and pretest trials. ☐ N/A for intervention sessions	Choose an item.
5	Provides praise contingent on an independent correct response for warm-up, interspersed, and intervention trials.	Choose an item.
6	Provides tangible contingent on an independent correct response for interspersed and intervention trials. ☐ 20 s interval +/- 3 seconds	Choose an item.
7	Secures attending to IF picture. (N/A for probes) ☐ Picks up target picture ☐ Waits 5 seconds→Says Look (if no attending)→Waits 5 seconds→Uses picture to guide attending→ continues until child has attended	Choose an item.
8	Provides the IF statement according to data sheet. (N/A for probes) ☐ Leaves picture up for 1 second	Choose an item.
9	Presents interspersed tasks as they appear on data sheet. ☐ N/A for intervention sessions	Choose an item.
10	Removes teaching materials as written. ☐ N/A for intraverbals	Choose an item.
11	Records data.	Choose an item.
12	Uses EC for warm-up, interspersed, and intervention trials. ☐ Represents SD with prompt ☐ Represents SD with no prompt ☐ Distractor task ☐ Represents SD with no prompt	Choose an item.
	Total +:	
	% of components performed with 100% integrity:	

	1	2	3	4	5	6	7	8	9
Independent Correct (not including interspersed/warmup)									

For Intervention Only	1	2	3	4	5	6	7	8	9
Echoic (+, -, Partial)									

APPENDIX B

PERCENTAGE OF TRIALS WITH AND WITHOUT ECHOICS WHEN IPAD WAS THE REINFORCER FOR CLARE


Percentage of Trials with iPad as Reinforcer
Echoics
28%
No Echoics
72%

APPENDIX C

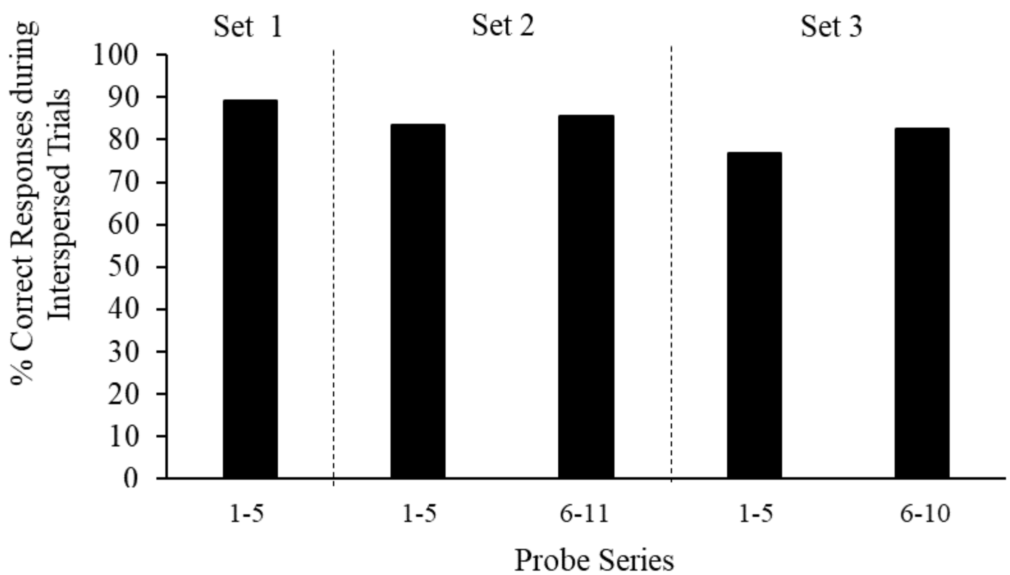
CLARE'S CORRECT RESPONDING DURING FEATURE LISTENER DISCRIMINATION AND TACT PROBES

Carrier Phrase	Set	Target	Correct Responses	
			Listener-by-name	Tact-by-name
Eats	1	Kibble	3/3	3/3
	2	Pollen	3/3	3/3
	3	Shrubs	3/3	3/3
Lives in	1	River	3/3	3/3
	2	Nest	2/3	3/3
	3	Forest	3/3	2/3
Babies	1	Calf	3/3	2/3
	2	Foal	3/3	3/3
	3	Fawn	3/3	3/3

APPENDIX D

PERCENTAGE OF CORRECT REPONSES TO INTERSPERSED TRIALS DURING

PROBES FOR CLARE


Set 1
Set 2
Set 3
% Correct Responses during Interspersed Trials
100
90
80
70
60
50
40
30
20
10
0
1-5
1-5
6-11
1-5
6-10
Probe Series

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